

REMARKS

Applicants have amended their claims in order to further clarify the definition of various aspects of the present invention. Specially, Applicants have amended each of claims 1 and 2 to recite that the carbonitride contained in the steel has a grain size of 100 nm or less. In light of these amendments to claims 1 and 2, claim 15 has been cancelled without prejudice or disclaimer. Claims 4 and 5 have been amended to recite that the processing forms austenitic stainless steel having carbonitride dispersed therein. In addition, claim 9 has been amended to provide consistency between the subject and verb, and claims 12 and 19 have been amended to recite mechanically "milled" powder, consistent with their parent claims.

Moreover, Applicants are adding new claims 20-25 to the application. Claim 20, dependent on claim 16 or 17, recites that the carbonitride has a grain size of 100 nm or less. Claim 21, dependent on claim 16 or 17, recites that the carbonitride is $M(C,N)$, wherein M is the at least one element as specified in the parent claims. Claims 22 and 23, dependent on claim 4 or 5, and on claim 22, respectively, respectively recites that prior to subjecting the mechanically milled powder to the processing which includes the consolidating, the mechanically milled powder is retained at a temperature of 400° to 650°C; and recites that the mechanically milled powder is retained at the temperature of 400°-650°C for 0.5-6 hours. Note the paragraph bridging pages 14 and 15 of Applicants' specification. Claims 24 and 25, dependent respectively on claim 16 or 17 and on claim 24, respectively recites that the steel is formed by processing including the additional step, prior to subjecting the mechanically milled powder to the process

which includes the consolidating, of retaining the mechanically milled powder at a temperature of 400°-650°C; and recites that the mechanically milled powder is retained at this temperature of 400°-650°C for 0.5 to 6 hours.

Applicants respectfully submit that the claims presented for consideration by the Examiner patentably distinguish over the teachings of the reference applied in rejecting claims in the Office Action mailed September 18, 2003, that is, the teachings of European Patent Specification No. EP 747,497, under the provisions of 35 USC §103.

It is respectfully submitted that the reference as applied by the Examiner would ~~have neither taught nor would have suggested such a corrosion-resistant, high-strength~~ austenitic stainless steel as in the present claims, having specified components, the steel being an austenitic stainless steel and having an average crystal grain size of 1µm or less, and wherein the steel contains carbonitride with a grain size of 100 nm or less dispersed therein. See claims 1 and 2. Note also claims 18 and 20.

Moreover, it is respectfully submitted that this reference as applied by the Examiner does not disclose, nor would have suggested, such a method for manufacturing a corrosion resistant, high strength austenitic stainless steel as in the present claims, including providing a mechanically milled powder of specified components and subjecting this mechanically milled powder to a process including at least consolidating the mechanically milled powder at 700°C to 900°C, so as to form an austenitic stainless steel with carbonitride dispersed therein; and would have neither taught nor would have suggested the corrosion resistant, high strength austenitic stainless steel, having the carbonitride dispersed therein, produced by this method. Note claims 4 and 5; see also claims 16 and 17.

In particular, it is respectfully submitted that the teachings of the applied reference would have neither disclosed nor would have suggested such a corrosion resistant, high strength austenitic stainless steel, as discussed in the foregoing, formed by the method as discussed above, and particularly wherein an average crystal grain size of the steel is 1 μ m or less (see claims 16 and 17), and/or wherein the stainless steel has carbonitride dispersed therein which has a grain size of 100 nm or less (see claims 18 and 20).

Furthermore, it is respectfully submitted that the teachings of the applied reference would have neither disclosed nor would have suggested such method of producing a corrosion resistant, high strength austenitic stainless steel as discussed previously, including the above-referred-to consolidating step, and further wherein the mechanically milled powder is retained at a temperature of 400°-650°C prior to subjecting the mechanically milled powder to the processing which includes the consolidating (note claims 22 and 24; see also claim 9); in particular, wherein such mechanically milled powder is retained at such temperature of 400°-650°C for 0.5-6 hours (see claims 9, 23 and 25; note that claim 9 recites that the powder, alternatively, has been suffered from a temperature rise from 400° to 650°C for a period of 0.5 to 6 hours).

Moreover, it is respectfully submitted that the applied reference would have neither taught nor would have suggested such a corrosion resistant, high strength austenitic stainless steel as in the present claims, including wherein the carbonitride is M(C,N), where M is the at least one element selected from the group consisting of Ti, Zr and Nb. See claim 21. Note also claim 13.

The present invention is directed to a corrosion resistant, high strength austenitic stainless steel and method of forming such steel, the steel being balanced so as to have good corrosion resistance and high strength, as well as having a desired toughness, for such material to have excellent use as a structural material.

As described in the second paragraph on page 1 of Applicants' specification, austenitic stainless steel has widely been used as a structural material because of its excellent corrosion resistance and workability; however, the steel is low in strength, in comparison with other types of structural steel. Moreover, it is inferior to other types of steel in use in a specific corrosive environment where pitting or stress corrosion cracking is likely to occur. While requests have been rising for high strength structural materials, it has been difficult to achieve high strength, while still achieving a high corrosion resistance of the austenitic stainless steel, and while also avoiding addition of specific alloy elements, such as yttrium, which complicate the refining process and lead to an increase in production cost. In addition, previous austenitic stainless steels do not have a desired level of toughness.

Against this background, Applicants provide a steel which is balanced in having both improved strength and high corrosion resistance, and also having good toughness. Applicants have found that these benefits are achieved through use of a steel as in the present claims, having the carbonitride dispersed in the steel, with the steel having an average crystal grain size of 1 μm or less; in particular, wherein the carbonitride is M(C,N) carbonitrides, and have a grain size of 100 nm or less. That is, in the steel having a relatively small average crystal grain size of 1 μm or less, having been obtained, for example, by consolidating a powder having its structure ultra-fined

by mechanical milling while controlling the crystal grain growth, for example, through use of the carbonitride, higher strength and higher corrosion resistance are achieved with less reduction of toughness; and nona-scale fine crystal grain structure is universally distributed. Note the paragraph bridging pages 40 and 41, as well as the first two paragraphs on page 41, of Applicants' specification.

A feature of the present invention is the average crystal grain size of the steel, which is ensured by precipitating the at least one of Ti, Zr and Nb as M(C,N) carbonitride, where M is the at least one of Ti, Zr and Nb, rather than wherein the at least one element is precipitated as a relatively coarser structure of $M_{23}(C,N)_6$.

According to the present invention, the carbonitrides control the grain growth during the consolidation process; and to provide the desired steel crystal grain growth, M(C,N) carbonitrides are to be precipitated. The carbonitrides $M_{23}(C,N)_6$ can be formed as carbonitrides that control the grain growth; however, formation thereof is undesirable because it adversely affects the anti-corrosion properties and toughness of the steel. Moreover, the M(C,N) carbonitrides may be fine enough (for example, 100 nm or less) to impart the desired properties to the steel. Large M(C,N) carbonitrides tend to be brittle and to be sparsely distributed; and, accordingly, such large carbonitrides do not provide as satisfactory results.

In addition, for providing the austenitic stainless steel having the various desirable characteristics due to, for example, crystal grain size and carbonitride structure, chemical components and thermal history during the manufacturing process achieves these results. For example, as the chemical components, the weight percentage ranges of Ti, Zr, Nb, C and N are defined; and when Ti, Zr and Nb are

added to the steel material, they are precipitated as M (C,N) carbonitrides, which serve for making the crystal grains finer. Excess addition of Ti, Zr and Nb results in embrittlement of the material. Excess amounts of C and N can give to rise to lowering of corrosion resistance. Thus, by utilizing materials, and weight percentage ranges, as in the present claims, the desired characteristics of corrosion resistance and high strength, as well as toughness, of the austenitic stainless steel are achieved. Note, for example, pages 20 and 21 of Applicants' specification.

Moreover, according to aspects of the present invention, the mechanically milled powder is retained at a temperature of 400°-650°C or, alternatively, rises in temperature through this temperature range, for, e.g., 0.5 to 6 hours, prior to consolidation of the mechanically milled powder. This further controls the grain growth of the steel, by precipitating the carbonitride and effectively pinning the intergranular transfer. Note the paragraph bridging pages 14 and 15 of Applicants' specification

In addition, by consolidating at a temperature of 700°C-900°C, transformation of the material into a deformation-induced martensite structure without inverse transformation can be avoided, and a fine grain structure of the stainless steel is achieved. Note page 15, lines 5-19, of Applicants' specification.

European Patent Specification No. EP 747,497 discloses an austenitic steel, in which a high corrosion-resistant austenitic steel is strengthened by making its crystal grain size ultra-fine. Note paragraphs [0022] and [0023] on pages 3 and 4 of No. 747,497. See also paragraphs [0024] and [0028] on page 4 of No. EP 747,497; and note the disclosure that by fining crystal grains of a material and introducing a large number of grain boundaries, the strength is increased, and the corrosion resistivity and

the resistivity against stress corrosion crack are increased and further the resistivity against radiation defect is improved. This patent document refers to the high strength austenitic sintered steel as claimed therein in claim 1, and a method of manufacture thereof as claimed therein in claims 5 and 6. Note paragraphs [0010] and [0013] on page 3 of this patent document. Claim 1 therein recites a high corrosion resistant and high strength austenitic sintered steel containing various components, with an average crystal grain size of the steel being not larger than 1 μm and the austenite phase representing not less than 90% in volume at room temperature. Claim 5 of this patent document discloses the method of manufacturing a high corrosion resistant and high strength austenitic sintered steel, which includes producing a processed powder having a crystal size smaller than 20 nm and deformation-reduced martensite transformation phase by mechanically grinding or alloying a powder at a temperature not higher than 100°C for 30 to 100 hours using an attriter or a ball mill, the powder containing specified components, and performing a hot densifying treatment or a hot solidifying treatment and a final hot working treatment at a temperature within a range of 700°C to 1050°C following the hot densifying treatment, through hot isostatic sintering or hot extruding working to the processed powder at a temperature within the range of 700°C to 1050°C, so that the densified steel contains austenite phase of not less than 90% by volume at a room temperature, an average crystal grain size of the phase being 10 nm to 1000 nm. Note claims 1 and 5 on pages 16 and 17 of No. EP 747,497.

It is respectfully submitted that the applied European Patent Specification does not disclose, nor would have suggested, a corrosion resistant, high strength austenitic stainless steel as in the present claims, including the precipitated carbonitride,

particularly wherein the carbonitride has a grain size of 100 nm or less, and advantages thereof as discussed in the foregoing.

Moreover, it is respectfully submitted that the applied reference does not disclose, nor would have suggested the method as in the present claims, with carbonitride precipitated; and/or retention at the temperature of 400°-650°C, and advantages thereof, as in the present claims.

The contention by the Examiner in the last paragraph on page 3 of the Office Action mailed September 18, 2003, that even though the applied reference does not ~~teach a steel alloy containing carbonitrides, such carbonitrides would be expected~~ because the composition and process steps are closely met, is respectfully traversed. It is respectfully submitted that the applied European Patent Specification does not even indicate inclusion of nitrogen, much less the forming of carbonitride. Moreover, clearly this European Patent Specification does not discuss advantages achieved through use of the carbonitrides, much less carbonitrides of the recited grain size, dispersed in the steel. Accordingly, it is respectfully submitted that the applied European Patent Specification does not disclose, nor would have suggested, the presently claimed subject matter. Contrary to the conclusion by the Examiner, it is respectfully submitted that the composition and the process steps according to the present invention are not "closely met" by the applied prior art, especially in light of advantages achieved by the present invention specifically due to differences between the disclosure of the European Patent Specification and the present invention.

Furthermore, it is not sufficient for the present invention that carbonitrides are included; rather, the carbonitrides according to the present invention are dispersed, in

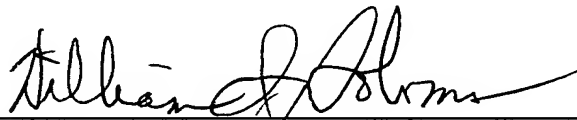
particular, at a specific size, which clearly would have neither been taught nor suggested by the applied reference.

In view of the foregoing comments and amendments, reconsideration and allowance of all claims remaining in the application are respectfully requested.

To the extent necessary, Applicants petition for an extension of time under 37 CFR § 1.136. Please charge any shortage in fees due in connection with the filing of this paper, including extension of time fees, to the Deposit Account No. 01-2135 (Case No. 500.41255X00), and please credit any excess fees to such Deposit Account.

Respectfully submitted,

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A handwritten signature in black ink, appearing to read 'William I. Solomon', written over a horizontal line.

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